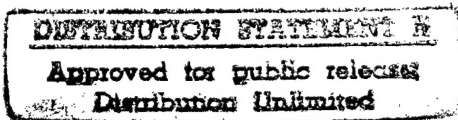


Report No. CG-D-16-96

**Remediation of Contaminated Media
at U.S. Coast Guard Facilities**

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**FINAL REPORT
June 1996**

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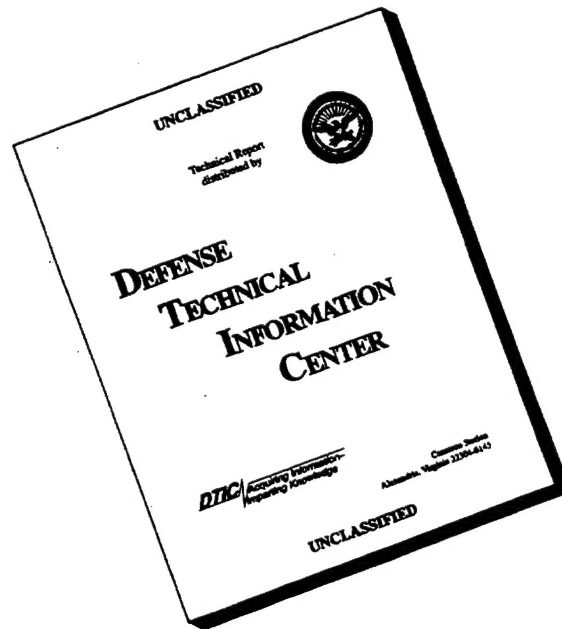
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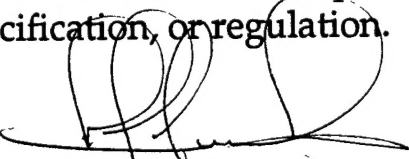
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Technical Report Documentation Page

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METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

| Symbol | When You Know | Multiply By | To Find | Symbol |
|----------------------------|------------------------|----------------------------|---------------------|-----------------|
| LENGTH | | | | |
| in | inches | * 2.5 | centimeters | cm |
| ft | feet | 30 | centimeters | cm |
| yd | yards | 0.9 | meters | m |
| mi | miles | 1.6 | kilometers | km |
| AREA | | | | |
| in ² | square inches | 6.5 | square centimeters | cm ² |
| ft ² | square feet | 0.09 | square meters | m ² |
| yd ² | square yards | 0.8 | square meters | m ² |
| mi ² | square miles | 2.6 | square kilometers | km ² |
| | acres | 0.4 | hectares | ha |
| MASS (WEIGHT) | | | | |
| oz | ounces | 28 | grams | g |
| lb | pounds | 0.45 | kilograms | kg |
| | short tons (2000 lb) | 0.9 | tonnes | t |
| VOLUME | | | | |
| tsp | teaspoons | 5 | milliliters | ml |
| tbsp | tablespoons | 15 | milliliters | ml |
| fl oz | fluid ounces | 30 | milliliters | ml |
| c | cups | 0.24 | liters | l |
| pt | pints | 0.47 | liters | l |
| qt | quarts | 0.95 | liters | l |
| gal | gallons | 3.8 | liters | l |
| ft ³ | cubic feet | 0.03 | cubic meters | m ³ |
| yd ³ | cubic yards | 0.76 | cubic meters | m ³ |
| TEMPERATURE (EXACT) | | | | |
| °F | Fahrenheit temperature | 5/9 (after subtracting 32) | Celsius temperature | °C |

* 1 in = 2.54 (exactly).

Approximate Conversions from Metric Measures

| Symbol | When You Know | Multiply By | To Find | Symbol |
|----------------------------|-----------------------------------|-------------------|------------------------|-----------------|
| LENGTH | | | | |
| mm | millimeters | 0.04 | inches | in |
| cm | centimeters | 0.4 | inches | in |
| m | meters | 3.3 | feet | ft |
| m | meters | 1.1 | yards | yd |
| km | kilometers | 0.6 | miles | mi |
| AREA | | | | |
| cm ² | square centimeters | 0.16 | square inches | in ² |
| m ² | square meters | 1.2 | square yards | yd ² |
| km ² | square kilometers | 0.4 | square miles | mi ² |
| ha | hectares (10,000 m ²) | 2.5 | acres | |
| MASS (WEIGHT) | | | | |
| g | grams | 0.035 | ounces | oz |
| kg | kilograms | 2.2 | pounds | lb |
| t | tonnes (1000 kg) | 1.1 | short tons | |
| VOLUME | | | | |
| ml | milliliters | 0.03 | fluid ounces | fl oz |
| l | liters | 0.125 | cups | c |
| l | liters | 2.1 | pints | pt |
| l | liters | 1.06 | quarts | qt |
| l | liters | 0.26 | gallons | gal |
| m ³ | cubic meters | 35 | cubic feet | ft ³ |
| m ³ | cubic meters | 1.3 | cubic yards | yd ³ |
| TEMPERATURE (EXACT) | | | | |
| °C | Celsius temperature | 9/5 (then add 32) | Fahrenheit temperature | °F |

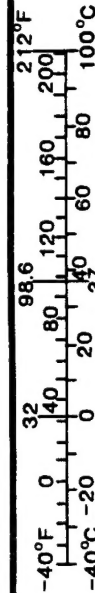


TABLE OF CONTENTS

| SECTION NUMBER | TITLE | PAGE NUMBER |
|-------------------|---|----------------|
| | LIST OF ACRONYMS | vi |
| 1.0 | INTRODUCTION | 1-1 |
| 2.0 | DATA COLLECTION METHODOLOGY | 2-1 |
| 3.0 | REMEDIAL TECHNOLOGIES AT USCG FACILITIES | 3-1 |
| 4.1 | Biodegradation | 3-2 |
| 4.2 | Bioventing | 3-8 |
| 4.6 & 4.18 | Soil Vapor Extraction | 3-14 |
| 4.10 | Composting | 3-22 |
| 4.12 | Landfarming | 3-24 |
| 4.21 & 4.24 | Thermal Desorption | 3-28 |
| 4.23 | Incineration | 3-32 |
| 4.29 & 4.50 | Natural Attenuation (Intrinsic Remediation) | 3-34 |
| 4.34 | Air Sparging | 3-40 |
| 4.37 | Free Product Recovery | 3-44 |
| 4.44 | Air Stripping | 3-48 |
| 4.47 & 4.55 | Carbon Adsorption | 3-50 |
| | Asphalt Cap | 3-52 |
| | Excavation | 3-54 |
| | Pump and Treat | 3-60 |

LIST OF ACRONYMS

| | |
|---------|--|
| AST | Aboveground Storage Tank |
| AVDET | Aviation Detachment |
| bgs | below ground surface |
| BTEX | Benzene, Toluene, Ethylbenzene, Xylene |
| CAP | Contamination Assessment Plan |
| CAR | Contamination Assessment Report |
| CEC | Cation exchange capacity |
| CARA | Contamination Assessment Report Addendum |
| CEU | Civil Engineering Unit |
| cfm | cubic feet per minute |
| cm | centimeter |
| cp | centipoise |
| DCE | Dichloroethane |
| DEQ | Department of Environmental Quality |
| DRMO | Defense Reutilization and Marketing Office |
| DRO | Diesel Range Organics |
| EPH | Extractable Petroleum Hydrocarbons |
| FD & CC | Facility Design and Construction Center |
| GAC | Granular Activated Carbon |
| gpd | gallons per day |
| gpm | gallons per minute |

| | |
|--------|---|
| gw | groundwater |
| H | Henry's Law Constant |
| HC | Hydrocarbon |
| Hg | Mercury |
| hp | horsepower |
| IRA | Initial Remedial Action/Interim Remedial Action |
| ISC | Integrated Support Command |
| K | Hydraulic conductivity |
| kg | kilogram |
| L | liter |
| LANT | Atlantic |
| LDPE | Low Density Polyethylene |
| Lorsta | LORAN Station |
| mg | milligram |
| mm Hg | millimeters of Mercury |
| MPN | Most Probable Number |
| NAPL | Non-aqueous Phase Liquid |
| ND | Not Detected |
| NSFO | Naval Special Fuel Oil |
| O&M | Operations and Maintenance |
| PAC | Pacific |
| PAH | Polycyclic Aromatic Hydrocarbons |

| | |
|--------|--|
| PCB | Polychlorinated biphenol |
| PCE | Polychloroethene |
| PES-31 | Proprietary Nutrient Supplement |
| PNUM | Project Number |
| POTW | Public-Owned Treatment Works |
| ppb | parts per billion |
| ppm | parts per million |
| psi | pounds per square inch |
| RAP | Remedial Action Plan |
| RPM | revolutions per minute |
| RTC | Reserve Training Center |
| S | Storativity |
| scfm | standard cubic feet per minute |
| SVE | Soil Vapor Extraction |
| STA | Station |
| SVOC | Semi-Volatile Organic Compound |
| T | Transmissivity |
| TBD | To Be Determined |
| TCE | Trichloroethane |
| TCLP | Toxicity Characteristic Leaching Procedure |
| TDS | Total Dissolved Solids |
| TKN | Total Kjeldahl Nitrogen |
| TOC | Total Organic Carbon |

| | |
|--------|--|
| TPH | Total Petroleum Hydrocarbons |
| Tracen | Training Center |
| TRPH | Total Recoverable Petroleum Hydrocarbons |
| UST | Underground Storage Tank |
| UV | ultraviolet |
| VOA | Volatile Organic Aromatic |
| VOC | Volatile Organic Compound |
| VP | Vapor Pressure |
| W | Watt |
| °C | degrees Celsius |
| °F | degrees Fahrenheit |

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This document, *Remediation of Contaminated Media at USCG Facilities*, was developed by the United States Coast Guard (USCG) Research and Development Center (RDC) in conjunction with the John A. Volpe National Transportation Systems Center (Volpe Center) and their consultant Environmental Transportation Consultants (ETC). This document summarizes information pertaining to remediation technologies practiced at USCG facilities and is intended to be used as a companion document to the *Remediation Technologies Screening Matrix and Reference Guide* (EPA/542/B-94/013).

1.1 PURPOSE

The *Remediation Technologies Screening Matrix and Reference Guide*, prepared by the Federal Remediation Technologies Roundtable, is intended to be used to screen and evaluate candidate cleanup technologies for contaminated installations and waste sites in order to assist remedial project managers in selecting a remedial alternative. While the Federal document gives a detailed description of remedial technologies being practiced at various federal installations, it does not provide specific information on USCG facilities. *Remediation of Contaminated Media at USCG Facilities* summarizes the USCG's remediation experience and provides a point of contact for future follow up.

The main purpose of this document is to provide USCG personnel with summarized information regarding the past, current and planned remedial technologies that are located at USCG facilities. This summarized information can help USCG personnel when making decisions regarding the selection of appropriate remediation technologies. A companion document, *Engineering Parameters for Environmental Remediation Technologies* includes a collection of engineering design parameters.

1.2 ORGANIZATION

This document has three sections. Section 1.0 is an introduction. Section 2.0 explains the methods used to gather the data on various projects at the USCG facilities. Section 3.0 summarizes information of various remedial technologies at the USCG facilities. The data provided is organized to follow the technology identifying number and title as given in the *Remediation Technologies Screening Matrix and Reference Guide*. The structure matches that of Tables 3-4 through 3-16 in Section 3 of the Guide.

DATA COLLECTION METHODOLOGY

Data pertaining to the remediation technologies at USCG facilities were collected through telephone interviews and personal site visits.

Telephone Interviews: Initially, the USCG - RDC contacted the CEUs, Facilities Design and Construction Centers (FD&CC); and Headquarter Unit Facilities Engineering Divisions and explained the intent of this document. This initiation by the USCG led to an understanding of the existence or non-existence of technologies at the USCG facilities. The Volpe Center and ETC prepared a checklist of technologies and two sets of data collection forms, Data Collection Form - I (to collect the general information of the site and the technology) and Data Collection Form - II (to collect specific information on engineering parameters for the technology in question). Copies of the Data Collection Form - I were mailed to the facilities mentioned above and information about the remediation technologies was obtained prior to the site visits.

Site Visits and Personal Interviews: The first site visit was conducted at CEU Providence, RI. This visit was the prototype and was followed by a workshop to determine the best approach for the remaining site visits. The RDC, Volpe Center and ETC participated in this site visit during which information on various technologies was collected by going through the various project related files and personal interviews. Information thus collected was reviewed during the workshop session along with the remaining data collection process.

Following the prototype site visit, site visits were conducted by the RDC and/or the Volpe Center/ETC at various USCG facilities that had available data pertaining to remediation technologies. Relevant information on the technologies was collected by going through the project related files located at each of these facilities and by conducting personal interviews. Information collected is presented in Section 3.0.

REMEDIAL TECHNOLOGIES AT USCG FACILITIES

Information about remedial technologies at USCG facilities is summarized and presented in this section. The information is summarized under the following headings:

- **Site Name/Contact** - This column provides the name of the facility, location of the site, USCG project number (PNUM) (where available), the dates projects began and/or were being performed, and the name of the contact person along with their telephone numbers.
- **Technology/Vendor** - The type of technology and the vendor who designed and/or installed it is mentioned here.
- **Media Treated** - This column explains what the type of media was treated.
- **Contaminants Treated** - Under this heading, the treated contaminants are mentioned.
- **Matrix Characteristics** - Some of the important characteristics such as soil type, and hydraulic conductivity are identified.
- **Operating Parameters** - Available operating parameters are listed in this column. More details can be found in the other document *Engineering Parameters for Environmental Remediation Technologies*.
- **Materials Handling** - Where applicable, materials handling issues are included.
- **Residuals Management** - Many technologies did not include residuals management. Where applicable, methods of residuals management are included.
- **Cost/Comments** - Any comment on the technology and/or the cost to operate this technology are included in this column.

4.1 Biodegradation (In-Situ and Ex-Situ)

| Site Name/ Contact | Technology/ Vendor | Media Treated | Contaminants Treated | Matrix Characteristics |
|--|-----------------------------------|-------------------------------|--|---|
| Army Diesel UST PNUM F4055 ISC Kodiak Kodiak, AK July 1997 FD&CC Mike Bowlus (206) 220-7370 | Biodegradation In-Situ | soil 1,300 yd ³ | DRO: 3,000 - 26,000 pp TPH: 43 - 2,100 ppm cleanup level: 100 ppm | silty, gravelly sand grain size: 0.1 - 20 mm bedrock: 15 - 25' bgs K: 0.002 cm/s moisture: 22.3 - 58.1% depth to gw: 5.7 - 6.7' bgs gw gradient: 0.08 ft/ft pH: 5.8 - 6.7 water data: iron: 18.7 - 521 ppm manganese: 1.2 - 19.4 ppm sulfate: 3.5 - 6.4 ppm TKN: 22.7 - 69.0 ppm phosphorus: 15 - 24.4 ppm TOC: 2.1 - 12.0% heterotrophic plate count: 28,100 col/g oil degrading bacteria: 2,510 MPN |
| PNUM 1836 Air Station Sitka Sitka, AK June 1994 CEU Juneau Bob Deering (970) 463-2440 | Biodegradation In-Situ | soil 5,000 yd ³ | petroleum HC's JP-5 fuel TPH: 150 - 10,350 ppm cleanup level: 1,000ppm | shot rock with granular soil bedrock: 5 - 12' bgs O ₂ : 5 - 21% CO ₂ : 0.05 - 9.1% |
| PNUM 33-X 3762 Aviation Hill Housing ISC Kodiak Kodiak, AK 1996 - 1997 FD&CC John Vogel (206) 220-7387 | Biodegradation Ex-Situ | Soil 8,000 yd ³ | heating fuel oil DRO: 3.1 - 5600 ppm BTEX: 0.043 - 11.29 pp TPH: 220 - 28,000 ppm cleanup level: 200 ppm | silty sandy gravel bedrock: 5' - 9' bgs depth to gw: 1.5' - 11.5' bgs air permeability: 10 E-7 - 10 E-8 cm ² |

4.1 Biodegradation (In-Situ and Ex-Situ)

| Operating Parameters | Materials Handling | Residuals Management | Cost/Comments |
|---|--|----------------------|---|
| | | | \$85,955 Release investigation. Pilot test planned for 1997. |
| estimated cleanup time: 3 yr semi-annual soil gas monitoring (O ₂ , CO ₂) to track biological activity. hand broadcast fertilizer: 10 - 15 lb/1000 ft ² every 3 months. (21% N, 3% P, 5% potash) | | | \$76,000 Release investigation \$10,210/yr Semi-annual samples |
| 2 cells 50' x 180' x (7'-8") 50' x 225' x (7'-8") 2% slope for runoff drainage 30 mil liner 12" sand above liner soaker hoses -H ₂ O and nutrients on top microbe mix PES - 31 added aeration pipes at bottom of pile leachate control recycles liquid to pile 10 mil top cover field capacity to be kept @ 75% Rotron blower - 100 cfm @ 10" of H ₂ O Ops @ 29-36 cfm @ 10" of H ₂ O | 4,300 yd ³ /pile before movement to biocell. | | \$70,000 Construct 2 cells \$50,000 Excavation |

4.1 Biodegradation (In-Situ and Ex-Situ)

| Site Name/ Contact | Technology/ Vendor | Media Treated | Contaminants Treated | Matrix Characteristics |
|--|--|-------------------------------|---|--|
| Bio Cell PNUM F4046 Nymans Peninsula ISC Kodiak Kodiak, AK August 1995 FD&CC PAC John Vogle (206) 220-7387 | Biodegradation Ex-Situ | soil 500 yd ³ | diesel | |
| RTC Yorktown Yorktown, VA March 3, 1996 RTC Yorktown Lynn Daniels (804) 898-2390 | Biodegradation Ex-Situ and/or thermal treatment Cherokee Environmental Group | soil 536 tons | diesel | |
| Bio cell PNUM J1170 Potato Point Valdez, AK 1993 - ongoing CEU Juneau Bob Deering (907) 463-2440 | Biodegradation Ex-situ | soil 1,400 yd ³ | petroleum HC's diesel TPH: 650 - 59,700 ppm | coarse gravelly sand (gravel: up to 2") peaty top soil: 3 - 4' depth to gw: 8 - 10' bgs |

4.1 Biodegradation (In-Situ and Ex-Situ)

| Operating Parameters | Materials Handling | Residuals Management | Cost/Comments |
|---|------------------------------|----------------------|--|
| cell 100' x 50' x 6' soil ht: 3' temp: > 40°F moisture content: 17 - 22% dry wt blower: 2 - 2 psi piping: 6" dia 2 levels: at bottom on top of surface sand base: 18 - 24" single sump; base @ 2 - 3% slope estimated soil cycle time: 6 months | | | \$ 27,646 O&M (1yr.) \$ 95,000 Construction |
| Process of heating waste to 1,700 °F for 12 hours. | | | \$30.50/ton Disposal cost Cost would have been a lot higher if material had to be shipped to a non-local site. (\$25,000) Vendor acceptance criteria: no metals. |
| regenerative blower: 1 hp 107 scfm max 57" of H ₂ O max pressure 52" of H ₂ O max vacuum 75' x 50' x 11' cell air supply: 1.25" dia pipe (2 levels) leachate collection: 4" dia pipe 5' on center spacing 4' vertical separation | monitoring every 2 weeks. | | \$89,637 Construction of biocell. |

4.1 Biodegradation (In-Situ and Ex-Situ)

| Site Name/ Contact | Technology/ Vendor | Media Treated | Contaminants Treated | Matrix Characteristics |
|--|---|--|--|------------------------|
| Bio cell PNUM 17-J5492 AVDET Cordova Cordova, AK 1995 CEU Juneau Bob Deering (907) 463-2440 | Biodegradation Ex-situ | soil 160 yd ³ 120 yd ³ placed in on site biocell. | petroleum HC's JP-5: 75 - 100 gallons (released) | depth to gw: 6' bgs |

4.1 Biodegradation (In-Situ and Ex-Situ)

| Operating Parameters | Materials Handling | Residuals Management | Cost/Comments |
|--|--------------------|----------------------|--|
| blower: 130 scfm moisture added: every 3 - 5 months biocell construction: pit w/ 20 mil liner and cover 24" contaminated soil pile 36' of 4" vent line 5' of 4" PVC as riser (surface penetration for bioventing system) excavation: 384' x 14' x 7' weekly inspection: blower, piping, cover, pressure, vacuum, temp. semi-annual soil gas, CO ₂ , O ₂ , and HC's. | | | \$ 6,200 Spill response/Biocell construction \$ 3,000 Annual monitoring \$ 2,000 Future site closure and sampling \$ 11,200 Total This is an on going project. Respiration rate will be determined in late spring. |

4.2 Bioventing

| Site Name/ Contact | Technology/ Vendor | Media Treated | Contaminants Treated | Matrix Characteristics |
|---|--|---|---|---|
| Site 6A - MOGAS PNUM F4016 ISC Kodiak Kodiak, AK July 1995 FD&CC Mike Bowlus (206) 220-7370 | Bioventing | soil 27,200 ft ² closed as landfill | JP-5, used oil waste solvents TPH: 14,200 ppm PCE: 3,500 ppb contaminants > background levels | sand, gravelly with silt (0.5 - 1.0" dia) 1' organic soil overlay fractured bedrock: 17 - 21' bgs K: 4.2 E-4 - 8.7 E-3 cm/s porosity assumed: 0.12 void volume: 48,000 ft ³ gw gradient: 0.02 - 0.88 ft/ft |
| PNUM 33-X 3762 Aviation Hill Housing ISC Kodiak Kodiak, AK 1996-1997 FD&CC John Vogel (206) 220-7370 | Bioventing | soil 8,000 yd ³ | heating fuel oil DRO: 3.1 - 5600 ppm BTEx: 0.043 - 11.29 pp TPH: 220 - 28,000 ppm cleanup sampling: 1 every 200 yd ² surface area. cleanup level: 200 ppm | silty, sandy gravel bedrock: 5 - 9' bgs depth to gw: 1.5' - 11.5' bgs air permeability 10 E-7 - 10 E-8 cm ² |
| PNUM 09-C0882 Air Station Traverse City, Traverse City, MI 1992 CEU Cleveland Frank Blaha (216) 522-3368 ext. 368 | Bioventing Reclamation Pilot Program Traverse Group 2525 Aeropark Drive Traverse City, MI | soil | petroleum HC's aviation gasoline fuel carbon: 100 - 900 ppm plume: 1,100' x 250' plots: 30' x 50' | beach sand: 0 - 50' bgs glacial silty clay: > 50' bgs moisture content: 3.5 - 23% depth to gw: 16' bgs water fluctuation: 2.5' (up to 6 - 8') treatment area: 30' x 50' temp: 3 - 21 °C |
| PNUM 0095 Air Station San Diego, San Diego, CA 1988 - 1995 CEU Oakland Dave Stalters or Joseph Sabel (510) 535-7239 Ref# TCN 0095- 09 | Bioventing To be implemented in mid 1996. Design completed by; Tetra Tech, Pasadena, CA Vendor: unknown | soil 185 yd ³ | petroleum HC's JP-5 TPH(gas): 3,500 ppm TPH(diesel): 39,100 pp benzene: 15 ppb toluene: 8 ppb ethylbenzene: 5 ppb xylene: 83 ppb naphthalene: 65 ppm | silty sand moisture content: 2.5 - 50.1% air permeability: 751 - 20,000 millidarcies pH: 6.9 - 8.4 HC oxidizing population: < 10 - 11,000 MPN/g ammonia nitrogen: 0.7 - 4.6 ppm nitrate nitrogen: 1.2 - 1.8 ppm orthophosphate: 3.5 - 12.2 ppm |

4.2 Bioventing

| Operating Parameters | Materials Handling | Residuals Management | Cost/Comments |
|---|------------------------------|---|--|
| bioventing 1.25" dia pipe regeneration blower (2ea) 35 CFM @ 50" H ₂ O 1.5 hp 10 - 25' pipe, 5 per side (perforated pipe) | | | \$ 97,262 Design \$ 12,583 Design review \$ 824,788 Construction \$ 92,873 UST liquid collection and disposal \$ 11,000 Const Insp Svcs \$ 358,251 Preclosure gw monitoring (1yr) |
| well spacing 25 - 35 ft intervals regenerative blowers 20 - 30 scfm 2" dia pipe | | | \$ 100,000 Construction \$ 12,000 Operation |
| air flow rate design: 5 - 63 cfm (actual 3 - 58 cfm) design radius of influence: 10' extraction pressure: 4 - 6" Hg injection pressure: 4 psi re-injection pressure: 6 psi | N, P, K added by sprinklers. | Oily residue is entrapped in capillary pores below water table preventing sufficient exposure to removal process. | \$ 50 Cost/ton \$50,035 Total (not including research) Objective of pilot test (1 yr study) evaluate 2 systems: 1) injection system only, and 2) injection/extraction/reinjection. Both performed satisfactory. Aviation gas still below water table. |
| min O ₂ /lb HC: 13 lb of atm air blower capacity: 30 scfm at 60" H ₂ O (max 92 scfm) flow: 2.5 scfm (injection wells) air temp: 25 - 120 °F discharge pressure: 30 - 50" H ₂ O operation speed: 3,450 rpm max hp: 1 inlet filter: 10 u air filter (dry) | In-situ | 1988: 430 yd ³ excavated and disposed. | \$122,000 Original total cost \$ 75,000 Low bid original cost break down: \$ 6,000 Work plan \$ 20,000 12 soil vent wells \$ 40,000 Inf. trench \$ 15,000 Water nutrient and blower system \$ 8,000 Closure report \$ 75,000 Estimated rem. cost |

4.2 Bioventing

| Site Name/ Contact | Technology/ Vendor | Media Treated | Contaminants Treated | Matrix Characteristics |
|--|--|------------------|---|--|
| Tank 191 ISC Kodiak Kodiak, AK December 1994 CEU Juneau Bob Deering (907) 463-2440 | Bioventing (1 yr pilot test) Parsons Engineering Sciences, Inc. Denver, CO | soil | petroleum HC's TRPH max: 3,400 ppm (18 - 19' bgs) benzene: ND toluene: ND ethylbenzene: 1,900 ppb (3 - 5' bgs) xylene: 6,200 ppb (3 - 5' bgs) | glacial deposits (silt/clay glacial tills) overlie slate bedrock; glacial deposits covered by post-glacial peats and organic soils that have been overlain by multiple volcanic layers. depth to gw: 15' bgs gw gradient: 0.14 ft/ft NW |
| Building T-2 PNUM J1833 ISC Kodiak Kodiak, AK May 95 - May 97 CEU Juneau Bob Deering (907) 463-2440 | Bioventing Ex-situ | soil | petroleum HC's EPH: 244 - 1060 ppm EPH soil: 550 - 2500 pp EPH gw: 44 ppm avg cont: 800 ppm | sandy gravel and gravelly sands with < 10% fines K: 500 - 4000 gpd/ft ² depth to gw: 5' bgs gw gradient: 0.001 ft/ft gw velocity: 0.45 - 3.6 ft/d |
| Building T-2 PNUM J1833 ISC Kodiak Kodiak, AK May 95 - May 97 CEU Juneau Bob Deering (907) 463-2440 | Bioventing In-situ | soil | HC contamination levels nearly 2,500 ppm | sandy gravel and gravelly sands with < 10% fines K: 500 - 4000 gpd/ft ² depth to gw: 5' bgs gw gradient: 0.001 ft/ft gw velocity: 0.45 - 3.6 ft/d |

4.2 Bioventing

| Operating Parameters | Materials Handling | Residuals Management | Cost/Comments |
|--|--|--|--|
| <p>designed radius of venting influence around central sir injection well: 30 - 40' (expected to exceed 90' in deeper soils). diameter of vent well: 4" (40 PVC) with 15' screen of 0.04" slot set at 5 - 20' bgs blower: 2.5 hp air flow rate: 26 scfm air permeability: 154 darcies radius of influence: 50' from vent well O₂ loss rates (mod): 0.0084%/min - 0.037%/min based on O₂ estimate 1,200 - 2,100 mg fuel/kg soil can be degraded. air field porosity: 0.3 lt/kg soil; 3.5 mg O₂/mg fuel.</p> | <p>soil samples taken from 35' radius and up to 90'.</p> | | <p>There is no PNUM because there is no cost to the USCG. Soil gas: (total volatile HC's) reduction from 400 to 140 ppm (in monitoring well) TVPH in soil after 1 yr reduced to ND limits. Respiration tests: initial biodegradation rate: 1,180 - 5,210 mg TPH/kg soil/yr 6 month biodegradation rate: 180 - 550 mg TPH/kg soil/yr 12 month biodegradation rate: 170 - 830 mg TPH/kg soil/yr</p> |
| <p>2 - 20 slot PVC horizontal pipes run the length of the material placed 8' deep. longest radius of influence: 15' across the pit regenerative blower: 160 cfm (rated at 145 scfm at 0" H₂O vacuum as installed 1,125 scfm at 20")</p> | <p>excavation: 43' x 30' x 12' periodic monitoring for the system performance.</p> | <p>system includes air filter to remove particles.</p> | <p>\$ 95,378 Release investigation \$ 6,756 CAP \$ 102,134 Total</p> |
| <p>Converted monitoring well receiving 70 cfm ambient air from Gaast R4 regenerative blower (rated at 88 scfm at 0" H₂O; installed at 66 scfm at 21"). Weekly monitoring of blower performance: vacuum, pressure, temp.</p> | | <p>system includes an air filter to remove particulates.</p> | <p>Cost part of bioventing ex-situ costs listed above.</p> |

4.2 Bioventing

| Site Name/ Contact | Technology/ Vendor | Media Treated | Contaminants Treated | Matrix Characteristics |
|---|---|------------------|---|--|
| Former Fuel Farm PNUM C3801 Air Station Elizabeth City Elizabeth City, NC 1992 CEU Cleveland Frank Blaha (216) 522-3368 ext. 368 | Hybrid of Vapor Extraction and Bioventing | soil and gw | petroleum HC's JP-4 release at fire station | dense clayey silt or silty clay: 0 - 5' medium fine silty sand or silty sand: 5 - 50' dense clay: 50 - 75' K: 0.0003 - 0.01 cm/s depth to gw: 5 - 6' bgs gw gradient: 0.01 - 0.03 ft/ft gw velocity: 10.5 ft/yr pH: 5.5 - 8.5 temp: 20 - 40 °C |

4.2 Bioventing

| Operating Parameters | Materials Handling | Residuals Management | Cost/Comments |
|--|--|---|--|
| air injection: 4.5 psig 85 scfm per well 1,800 scfm blower with 75 hp motor vapor extraction: 35 - 50 scfm/well 800 scfm vacuum pump with 30 hp motor typical system: 1 to 3 psi 3 to 30" H ₂ O vacuum | Visibly stained soil and water removed with fuel tank removal. O ₂ , CO ₂ , temp, TPH monitored on extracted air to monitor biodegradation and volatilization rate. | Pulsing done every 3 months by using injection wells for extraction and extraction for injection. | \$ 250,000 Construction \$ 94,600 O&M (2 yrs) \$ 33,800 System removal Designed to lower water table to expose contaminated soil. Clean TPH level < 100 ppm. Monitoring and evaluation support provided by EPA. |

4.6 (In-Situ) and 4.18 (Ex-Situ) Soil Vapor Extraction

| Site Name/ Contact | Technology/ Vendor | Media Treated | Contaminants Treated | Matrix Characteristics |
|--|--------------------------|---|--|--|
| Site 3-laundry A PNUM F4020 ISC Kodiak Kodiak, AK July 1996 FD&CC PAC Mike Bowlus (206) 220-7387 | Soil Vapor Extraction | Soil 65,600 ft ³ | PCE: 0.02 - 1,700 ppm TCE : 0.065 - 0.380 pp 1,2-DCE: 0.190 ppm vinyl chloride: 0.22 ppm chlorethylene: 1.1 ppm TPH: 60 - 260 ppm | sandy silt & poorly graded gravel 0 - 5' bgs fractured bedrock 5' - 15' bgs K: 0.02 - 3.86 cm/s porosity: 0.12 void volume: 7,900 ft ³ depth to gw: 2' - 3.86' bgs perched aquifer TOC: < .21 - 1.1% CEC: 3930 - 8750 mg/kg |
| Site 7A Barrel Storage 1 PNUM F4201 ISC Kodiak Kodiak, AK July 1996 FD&CC PAC Mike Bowlus (206) 220-7387 | Soil Vapor Extraction | Soil: area 27,000 ft ² | JP-5, FS-6, TCE 1-1-1 TCE carbon tetrachloride methylene chloride paint wastes, PCE TPH: 43-91,000 ppm Lead: 7.2 - 93.5 ppm 1,2 - DCE: 10,000 ppb TCE: 12-1,600 ppb | fibrous peat 0 - 1' poorly sorted gravel 1' - 8' gravelly clay >8' K: 3.5 E-6 - 3.5 E-4 cm/s depth to gw: 5' - 14.5' bgs pH: 5.9 - 9.1 temp: 1-15.3°C yearly hardness: 59 - 515 mg/L O ₂ : 1.2 - 5.5 mg/L TOC: 1.0 - 24.6 mg/L iron : 25.9 - 277 mg/L Mg: 0.96 - 10.9 mg/L Conductance: 35 - 210 umhos/cm |
| Fuel Farm PNUM M1055 Base Miami Beach Miami, FL 1996/97 FD&CC LANT Jim Lewis (804) 858-6230 ext. 255 | Soil Vapor Extraction | Soil | TPH (diesel): 27,500 ppm max. 2,750 ppm avg. est. VOC: 1,534 gal. depth of contaminant: 20' | sand, fine silty sand K (vadose zone): 0.011 cm/s K: 7.1E-5 cm/s effective porosity: 0.25 soil density: 1.4 ton/yd ³ permeability: 3.8E-6 - 1.0E-4 ft/s depth to gw: 3' - 9' bgs (tidal Influence) gw flow towards bay aquifer thickness: 15' pH: 7.5 - 8.1 transmissivity: 3,366 gpd/ft |

4.6 (In-Situ) and 4.18 (Ex-Situ) Soil Vapor Extraction

| Operating Parameters | Materials Handling | Residuals Management | Cost/Comments |
|---|--------------------|--|---|
| 16 extraction air chimneys 12" dia, 8' x 8' spacing 1 extraction well 2" dia 8' x 8' spacing 8" SVE pipe in porous med. above chimney under cap operates @ 610 cfm extraction fan 650 cfm @ 41 " H ₂ O | | SVE filters (air): 4 ea. - 750 #GAC units in series bed area: 7.5 ft ² (ea.) Q: 750 cfm 6" H ₂ O drop per drum water scrubber: 000#GAC 30 lb/ cu. ft. pellets 8 x 30 mesh filters liquid from knockout tank (55 gal drum) | |
| SVE 2" dia. pipe centrifugal blower: 2400 scfm @ 40" H ₂ O vacuum 5,500 RPM, 50 HP, 3" dia 55 wells: approx. 10' x 10' spacing | | knockout pot tank (38.5 cu ft) water processed through 2 GAC filters in series then returned in air sparging GAC 4000# each 51#/cu. ft. 60% active 4 x 8 mesh size | \$ 89,770 Debris removal \$ 163,368 Soil removal (1st closure attempt) \$ 5,033 Project oversight -soil removal \$ 66,000 Design \$ 850,000 Construction (estimated) |
| Air flow rate 400 cfm Vacuum 37 in water (60) Typical depth of extraction well: 4 ft (pilot) Treatment required for air emissions thermal oxidizer 4 horizontal wells Radius of influence: 15 ft | | | \$194,000 capital (est) \$290,000 O&M |

4.6 (In-Situ) and 4.18 (Ex-Situ) Soil Vapor Extraction

| Site Name/ Contact | Technology/ Vendor | Media Treated | Contaminants Treated | Matrix Characteristics |
|--|---|-------------------------------|---|---|
| Fuel Farm PNUM M1055 Base Miami Beach Miami, FL July 92 -Sept. 95 CEU Miami Sonia Reyes/ Rob Kappel (305) 278-6700 | Soil Vapor Extraction | Soil 1,163 yd ³ | petroleum HC's gas diesel | sand, fine silty sand K(vadose zone): 0.011 cm/s K: 7.1E-5 cm/s effective porosity: 0.25 soil density: 1.4 ton/yd ³ permeability: 3.8E-6 - 1.0E-4 ft/s depth to gw: 3'-9' bgs aquifer thickness: 15' pH: 7.5 - 8.1 transmissivity: 3,366 gpd/ft |
| SARDET Holland PNUM C9125 Holland, MI Jan. 1991 - Feb. 1992 CEU Cleveland Denise Hancsak (216) 522-3934 (ext.267) | Soil Vapor Extraction The Traverse Group, Inc. 3772 Plaza Dr. Suite 5 Ann Arbor, MI 48108 (313) 747-9300 Ann Markstrom | soil | petroleum HC's diesel fuel waste oil BTEX PNA oil & grease TPH | medium, fine sand 0 - 9' bgs silty layers below 9' bgs depth to gw: 8' bgs |
| PNUM C0860 Base Milwaukee Milwaukee, WI Feb. 1996 CEU Cleveland Denise Hancsak (216) 522-3834 | Soil Vapor Extraction | soil | Petroleum HC's gasoline diesel Soil: DRO Water: BTEX ethylbenzene DRO | clay to silty clay 1-7 ft bgs silty sand below 7' bgs K: 6.9E-4 cm/sec depth to gw: 5'-10' bgs |
| PNUM 09-C0805 STA Little Creek Norfolk, VA 1992 CEU Cleveland Denise Hancsak (216) 522-3934 ext.267 | Soil Vapor Extraction EA Engineering Science and Technology 15 Loveton Circle Sparks, MD 21152 (410) 771-4950 | soil | petroleum HC's BTEX | K: 0.66 - 3.11 cm/s porosity: 25% depth to gw: 8' - 10' bgs gw fluctuation: 0.3' - 1.3' gw gradient: 1.2E-3 ft/ft perched gw: 5' - 8' bgs gw linear velocity: 1.6E-2 - 7.4E-2 ft/day transmissivity: 107 -505 ft ² /day aquifer thickness: 15' |

4.6 (In-Situ) and 4.18 (Ex-Situ) Soil Vapor Extraction

| Operating Parameters | Materials Handling | Residuals Management | Cost/Comments |
|---|--|--|--|
| 4 wells air flow rate: 100 - 400 cfm radius of influence: 15' | In situ In conjunction with pump and treat system. | SVE gas will be filtered and vented to the atmosphere first 2 months thermal oxidation of vapor | See pump and treat for total project costs, pg 3-61 |
| SVE vacuum: 0.4"-1.6" of H ₂ O blower avg: 42 scfm sparging radius of influence: 6' SVE radius of influence: 10' | biweekly monitoring: BTEX PNAs O ₂ OVM readings | Off gas treatment GAC canisters 441 ft ³ of soil landfilled | \$75.00/ yd ³ disposal cost (unit) |
| 2 extraction wells 2" dia. | in situ | | \$ 50,000 site assessment \$ 81,000 remedial design \$130,000 install remedial system \$ 56,000 O&M/testing (1yr) |
| blower: 30 cfm at 80" H ₂ O | in situ | carbon adsorption system for air | passive skimmer device is proposed under Phase III assessment. |

4.6 (In-Situ) and 4.18 (Ex-Situ) Soil Vapor Extraction

| Site Name/ Contact | Technology/ Vendor | Media Treated | Contaminants Treated | Matrix Characteristics |
|--|--|------------------------------|--|---|
| Former Fuel Farm PNUM C3802 Air Station Elizabeth City Elizabeth City, NC CEU Cleveland Jim Vardy (919) 335-6847 | Soil Vapor Extraction - Wind driven turbines Engineering- Science, Inc One Harrison Pk 401 Harrison Oaks Blvd., Suite 305 Cary, NC 27513 (919) 677-0080 Donald Boyle | soil in situ | Petroleum HC's Fuel (POL), JP-5 TPH, BTEX, VOAs, SVOAs TPH: 50.8-6490mg/kg VOA: >10 ppm SVOA: >40 ppm free product levels: 0.5'-4.5' (est. several 100,000 gallons) cont. area: 3.4 acres | clay, silty loam 0 - 5' bgs silty fine sand 5'-67' bgs K: 0.02 - 1.28 cm/s porosity: 25% moisture 16.4-25.3% depth to gw: 8'-9' bgs gradient 1.0E-3-5.0E-3 ft/ft pH 4.6-7.0 temp 10.9-16.6 °C O ₂ : 0.45-3.3 mg/l horiz. perm. 4.5E-10 |
| Lorsta St. Paul PNUM J3866 Saint Paul, AK May 1995 CEU Juneau Bob Deering (907) 463-2440 | Soil Vapor Extraction Arctic Slope Consulting Group | soil: 500 yd ³ | Petroleum HC's, Fuel Oil, JP-5, Heating Oils most contaminant: 0 -5' bgs BTEX: ND-7.7ppm EPH: ND-7380 ppm B: ND-0.042 ppm | soil: 1-3ft boulders in fine grained matrix with dense silt lenses depth to gw: 5' - 15' bgs |
| Fire Station PNUM C3801 Air Station Elizabeth City Elizabeth City, NC 1992-1993 CEU Cleveland Jim Vardy (919) 335-6847 | Soil Vapor Extraction | soil | petroleum HC's JP-4 product found @: 3.5' to 9' bgs | Sand with silt and clay (stiff to loose) K: 2 ft/day gw gradient: 0.01-0.03 ft/ft |

4.6 (In-Situ) and 4.18 (Ex-Situ) Soil Vapor Extraction

| Operating Parameters | Materials Handling | Residuals Management | Cost/Comments |
|---|--------------------|--|--|
| 1 riser every 150 ft of horizontal pipe 12" wind turbine on 4" dia. pipe turbine flow 4-61 cfm each (16 turbines) 8- 320' trench radius of influence: 25' - 30' | in situ | passive vapor extraction: straight off gas air monitoring required | \$ 100,000 construction \$ 31,600 annual maintenance |
| | in situ | | \$ 76,000 assessment report soil vapor extraction proposed testing to begin summer 1996 |
| 8- 320' trenches operable pressure: 4.5 psi Min. reliable flow rate: 87 cfm (5" dia. pipe). | in situ | straight off gas | operation stopped due to high water table resulting from antecedent rainfall events. removed > 400 lb hydrocarbons. |

4.6 (In-Situ) and 4.18 (Ex-Situ) Soil Vapor Extraction

| Site Name/ Contact | Technology/ Vendor | Media Treated | Contaminants Treated | Matrix Characteristics |
|--|--|---|---|--|
| Lorsta Pt. Clarence PNUM J1831 Port Clarence, AK August 1995 CEU Juneau Bob Deering (907) 463-2440 | Soil Vapor Extraction | soil | petroleum HC's diesel Fuel EPH: 780-14,000 ppm BTEX: 2.26-25.90 ppm | Gravelly sand, gravel 0.5" -1.0 dia. permafrost: 10' - 15' bgs depth to gw: 10' - 15' bgs (thin layer of gw above permafrost) |
| PNUM C0882 Air Station Traverse City Traverse City, MI 1990-1992 CEU Cleveland Frank Blaha (216) 522-3368 | Soil Venting System - Vacuum Extraction Traverse Group, Inc. 2525 Aeropark Dr Traverse City, MI | soil: 2 feet above gw table 2 feet below gw table | petroleum HC's aviation gas max. conc.: 10,000 mg/kg 15,000-17,000 gal. in plume | Uniform beach sand to gray glacial silty clay K: 30.5 cm/s |

4.6 (In-Situ) and 4.18 (Ex-Situ) Soil Vapor Extraction

| Operating Parameters | Materials Handling | Residuals Management | Cost/Comments |
|---|--------------------|---|---|
| wells: 5 injection 5 extraction air flow: 60 - 65 scfm vacuum: 4" - 10" H ₂ O temp.: 43° F CO ₂ : 1-4% O ₂ : 13-21% air injection: all year vapor extraction: only in summer. Thermistor strings to monitor permafrost. | | vented to atmosphere | \$ 48,492 investigation \$ 89,506 CAP \$ 22,388 SVE/biovent system Well placement constrained by existing structures and utilities set at 100 ft radii. |
| sys. flow rate: 150 cfm Inj. flow rate: 209 scfm (avg.) injection blower pressure: 1.25-1.5 psi vacuum for withdrawal blower <2 in to 7 in temp.: 40°F radius of influence: 50'-73' daily monitoring | | GAC bed to treat off gas Carbon usage 5.5lb of carbon per pd of contamination. Extracted vapors incinerated using re-fitted torvex catalytic incinerator | \$ 8,789 incinerator cost \$ 112,607 carbon usage \$ 168,910 carbon for entire project soil venting system removed 425 gallons contamination in 5 years |

4.10 Composting

| Site Name/ Contact | Technology/ Vendor | Media Treated | Contaminants Treated | Matrix Characteristics |
|--|---|--------------------------------------|--|---|
| <p>Tracen Petaluma Contract No. DTCG49-94-RQEN0 Delivery Order #7 Petaluma, CA</p> <p>July 1996</p> <p>Tracen Petaluma Patrick Nelligan (707) 765-7225</p> | <p>Composting PES Environmental Inc. 1682 Novato Blvd. Suite 100 Novato, CA 94947 (415) 899-1600</p> | <p>soil 1,000 yd³</p> | <p>TPH: 80 - 740 ppm cleanup target: 200 ppm</p> | <p>20% rock sandy clay, silty sand gw gradient: 0.006 ft/ft pH: 4.3 - 8.1</p> |

4.10 Composting

| Operating Parameters | Materials Handling | Residuals Management | Cost/Comments |
|--|--------------------|----------------------|--|
| windrow pile length: 1000' windrow size: 6' H x 12' W additives 250 - 300 yd ³ compost (lawn clippings & wood chips) 25 - 30 yd ³ (manure) nutrients added inlifts central 4" dia drain pipe nitrogen target 20 ppm phosphorus 5 ppm 20 mil bottom liner w/ 6" native soil cover 1.5' perimeter berm 10 mil cover recycle leachate through drip irrigation system moisture: 50-60% saturation windrow to be periodically turned windrow temp: 50 - 55 °C monitor conditions monthly | front end loader | | \$ 25,616 Remediation plan design (includes soil sampling) \$ 10,000 Composting \$ 5,000 Pile spreading after composting Plan approval by regulators pending. |

4.12 Landfarming

| Site Name/ Contact | Technology/ Vendor | Media Treated | Contaminants Treated | Matrix Characteristics |
|--|--|-----------------------------|--|--|
| Aviation Hill Housing PNUM ISC Kodiak Kodiak, AK FD&CC John Vogel (206) 220-7387 | Landfarming (In-Situ) | soil | petroleum HC's | |
| Fuel Farm Air Station Miami PNUM M0091 Opa Locka, FL 1990 - 1995 CEU Miami Zonia Reyes (305) 278-6700 | Absorbent Collection and Excavation (Landfarm) Law Environment (607) 698-3400 | soil 145 yd ³ | petroleum HC's TRPH: 228 ppm | depth to gw: 4 - 5' bgs fluctuation: 1' K: 63.0 - 66.5 cm/s gw gradient: 0.0001 ft/ft gw flow: NW |
| Former Fuel Farm PNUM C3802 Air Station Elizabeth City Elizabeth City, NC CEU Cleveland Jim Vardy (919) 335-6847 | Landfarming Engineering- Science, Inc. One Harrison Park 401 Harrison Oaks Blvd suite 305 Cary, NC 27513 (919) 677-0080 Donald Boyle | soil | petroleum HC's fuel (POL) JP-5 BTEX VOA's TPH: 50.8 - 6,490 pp contaminated area: 3.4 acres (> 10 ppm VOA, > 40 ppm SVOA) free product levels: 0.5 - 4.5' (estimate several hundred thousand gallons) | clay, silty loam: 0 - 5' bgs silty fine sand: 5 - 67' bgs K: 0.001 - 0.018 cm/s moisture content: 16.4 - 25.3% porosity: 25% depth to gw: 8 - 9' bgs gw gradient: 0.001 - 0.005 ft/ft pH: 4.6 - 7.0 temp: 10.9 - 16.6 °C dissolved O ₂ : 0.45 - 3.3 mg/L horiz perm: 4.5 x 10 E-10 radius of influence: 25 - 30' |
| PNUM P 1813 Air Station Brooklyn Brooklyn, NY 1990 completed 7/8/94 CEU Providence Rachel Marino (401) 736-1746 | Landfarming Texto, Inc. 40 Stone Castle Rd. Rock Terem, NY 12575 | soil 384 yd ³ | petroleum HC's JP-4 fuel TPH: ND - 2,800 ppm (avg 534 ppm) | moisture content: 60 - 70% pH: 7 - 9.9 CEC: 5.2 meq/100 g |

4.12 Landfarming

| Operating Parameters | Materials Handling | Residuals Management | Cost/Comments |
|--|---|-------------------------------------|---|
| | | | \$190,000 Tank removals \$ 30,000 Landfarm |
| contaminated soil was spread out on visquene sheets to volatilize the residual fuel content. | initial cleanup: absorbent collection and excavation (145 yd ³) | Intrinsic remediation for gw. | |
| single 4" lift over 3.7 acres bi-annual composite sampling at 8 locations cleanup level: 10 ppm VOA 40 ppm SVOA project duration: 2 yrs | tilling 1, 2, 6, 6, etc., months wood chips added for bulking | veg cover in 60 days | \$ 18,200 Spreading and tilling \$ 5,000 Sampling every 6 months until clean |
| soil lifts: 18" area: 220' x 220' nutrient ratio: 300:15:1 pH: 6.5 - 8 maintained endpoint: TPH 100 ppm | Monitoring of pH, moisture and nutrients. Weekly tilling. Monthly monitoring of TPH | Used as a cover for a MSW landfill. | \$148,000 Lump sum contract, (1990). |

4.12 Landfarming

| Site Name/ Contact | Technology/ Vendor | Media Treated | Contaminants Treated | Matrix Characteristics |
|---|-----------------------|----------------------------|--|------------------------------|
| PNUM J5492 AVDET Cordova Cordova, AK 1993 CEU Juneau Bob Deering (907) 463-2440 | Landfarming | soil 60 yd ³ | petroleum HC's heating oil TPH: 11,600 ppm | glacial till with rocks > 2" |

4.12 Landfarming

| Operating Parameters | Materials Handling | Residuals Management | Cost/Comments |
|---|---------------------|----------------------|---------------|
| soil spread out on 20 mil liner: 1' x 50' x 50' | tilling once a week | | Completed |

4.21 (High) and 4.24 (Low) Temperature Thermal Desorption

| Site Name/ Contact | Technology/ Vendor | Media Treated | Contaminants Treated | Matrix Characteristics |
|---|--|---|--|---|
| Fire Fighting School PNUM 2081 RTC Yorktown Yorktown, VA March 3, 1996 RTC Yorktown Lynn Daniels (804) 898-2390 | Thermal Desorption Rickmond Enviro | soil: 336 yd ³ stone: 224 yd ³ | diesel | |
| Peanut Island PNUM M1045/46 Sta. Lake Worth Inlet Riviera Beach, FL May 1995 CEU Miami Zonia Reyes (305) 278-6700 | Low Temperature Thermal Desorption Tanktek 14512 N. Nebraska Suite 104 Tampa, FL 33613 Mr. Jack Keiser (813) 971-4664 | soil: 107 ton 93 yd ³ | bilge H ₂ O/oily waste petroleum HC's TPH: 50 - 1,000 pp PAH: 12 - 37,000 pp VOA: < 1 - 6,100 pp TRPH: 4,500 - 42,000 ppm | fine sand with rubble soil size: < 2" depth to gw: 3.5 - 4' bgs (tidal influence) pH: 7.6 - 7.8 smear zone: 1.5' |
| PNUM M4321 Sta. Destin Destin, FL May 1993 CEU Miami Zonia Reyes (305) 278-6700 | Thermal Desorption Falcon Industries Rte. 4, Box 348 Brewton, AL 36426 | soil: 31.3 tons 3,413 ft ³ | petroleum HC's diesel fuel | fine-med sand depth to gw: 1.4 - 4.3' bgs (tidal influence) gw gradient: 0.004 ft/ft TDS: 380 - 460 mg/L |
| Sta. Fort Myers PNUM M1388 Fort Myers, FL Feb 1993 CEU Miami Zonia Reyes (305) 278-6700 | Thermal Desorption South Florida Thermal Services 1 Formoor Lane P.O. Box 309 Moore Haven, FL (813) 946-3300 | soil: 80 tons 1530 yd ³ | petroleum HC's waste oil BTEX: 2951 ug/L | fine-med sand K (@12' bgs): 5 - 7 cm/s K (@33' bgs): 9 cm/s porosity: 0.30 (clean sand) depth to gw: 5 - 6' bgs gw gradient: horiz: 0.03 ft/ft vert: 0.04 - 0.23 ft/ft pH: 6.78 - 8.27 TDS: 550 - 9,000 mg/L |

4.21 (High) and 4.24 (Low) Temperature Thermal Desorption

| Operating Parameters | Materials Handling | Residuals Management | Cost/Comments |
|----------------------|--|--|--|
| | | | Most costs and volumes were below the government estimates of \$60,000. |
| backhoe excavation | barge transport off island truck to off site STTF (treat. fac.) | <50 ppm residual is clean for gasoline group | \$ 60,000 Assessment \$ 20,862 Removal and gw monitoring \$ 24,960 Excavation and treatment |
| | ex-situ | | \$ 27,000 CAR \$ 45/ton Thermal treatment |
| | ex-situ | | \$46,689 CAR \$11,583 Monitoring plan \$ 3,711 Initial assessment \$5,407/yr qrtly monitoring |

4.21 (High) and 4.24 (Low) Temperature Thermal Desorption

| Site Name/ Contact | Technology/ Vendor | Media Treated | Contaminants Treated | Matrix Characteristics |
|--|---|---|--|---|
| Lorsta Pt. Clarence PNUM J1831 Pt. Clarence, AK August 1995 CEU Juneau Bob Deering (907) 463-2440 | Low Temperature Thermal Desorption portable rotary kiln | soil: 360 yd ³ | petroleum HC's diesel fuel EPH: 780 - 14,000 ppm BTEX: 2.3 - 25.9 ppm | gravelly sand w/ gravel: 0.5 - 1" depth to gw: 10 - 15' bgs (thin layer of gw on top of permafrost) depth to permafrost: 10 - 15' bgs |
| Lorsta Tok PNUM J1884 Tok, AK June 1995 CEU Juneau Bob Deering (907) 463-2440 | Low Temperature Thermal Desorption portable rotary kiln | soil 200 yd ³ | petroleum HC's No. 1 fuel oil TPH: 210 - 2,400 ppm | sand: 3 - 7' bgs sandy gravel 7 - 9' bgs gravel with cobbles: 9 - 20' bgs depth to gw: 86 - 100' bgs gw gradient: 0.001 ft/ft depth to permafrost: 8 - 15' bgs |
| PNUM J1836 Air Station Sitka Sitka AK February 1993 CEU Juneau Bob Deering (907) 463-2440 | Low Temperature Thermal Desorption portable rotary kiln | soil: 610 yd ³ | petroleum HC's JP-5 fuel TPH: 5,000 ppm | |
| PNUM M4336 Sta. Panama City Panama City, FL July 1994 CEU Miami Zonia Reyes (305) 278-6700 | Thermal Treatment Kleensoil International 13838 Harlee Road Palmetto, FL 43221 (800) 926-9677 | soil 25.39 yd ³ 32.54 tons | petroleum HC's diesel: 300 - 400 ppm PAHs: 5,261 ppb VOAs: 1,400 ppm | med-fine silty sand depth to gw: 2.5 - 6.5' bgs (tidal influence) pH: 5.4 - 6.9 temp: 22 - 28 °C |

4.21 (High) and 4.24 (Low) Temperature Thermal Desorption

| Operating Parameters | Materials Handling | Residuals Management | Cost/Comments |
|--|--|--|--|
| operating temp: 600 °F after burner: propane or natural gas temp: 800 - 1,200 °F soil treated: max size: 3" max vol dry: 8 yd ³ /day max vol wet: 4 yd ³ /day max contam. soil processed: 5,000 ppm TPH | ex-situ treatment of 7 yd ³ /day for 51 days. | vented to atmosphere after treatment soil reused on site @ TPH < 50 ppm | Test burned samples every 100 yd ³ . |
| operating temp: 600 °F after burner: propane or natural gas temp: 800 - 1,200 °F soil treated: max size: 3" max vol dry: 8 yd ³ /day max vol wet: 4 yd ³ /day max contam. soil processed: 5,000 ppm TPH | ex-situ treatment | after treatment: TPH < 50 ppm | \$26,936 Investigation rpt. \$ 6,160 Sampling |
| operating temp: 600 °F after burner: propane or natural gas temp: 800 - 1,200 °F soil treated: max size: 3" max vol dry: 8 yd ³ /day max vol wet: 4 yd ³ /day max contam. soil processed: 5,000 ppm TPH | treated 7 yd ³ of soil per day and sampled every 100 yd ³ . | after treatment: soil returned to excavation site TPH < 50 ppm | \$40,000 Kiln operation \$ 2,553 Soil sampling |
| | ex-situ | | \$24,290 IRA (soil removal) \$ 6,140 Groundwater and soil sampling |

4.23 Incineration

| Site Name/ Contact | Technology/ Vendor | Media Treated | Contaminants Treated | Matrix Characteristics |
|--|--|-----------------------------|-------------------------|------------------------|
| Lorsta Martha's Vineyard Gay Head, MA 1995 CEU Providence Rachel Marino (401) 736-1746 | Incineration SI: Keyes Assoc., Lincoln, RI and Franklin Env. Services Wrentham, MA Disposal Facility: Chem. Waste Management Port Arthur, TX | soil 100 yd ³ | PCBs: 0.28 - 8,000ppm | |

4.23 Incineration

| Operating Parameters | Materials Handling | Residuals Management | Cost/Comments |
|----------------------|---------------------------------------|--|---|
| | Excavation and off site incineration. | All residuals tested after incineration: < 5 ppm | \$2,500 - \$3,000/yd ³ (unit price) |

4.29 (Soil) and 4.50 (Water) Natural Attenuation

| Site Name/ Contact | Technology/ Vendor | Media Treated | Contaminants Treated | Matrix Characteristics |
|--|--|--------------------------------|--|--|
| UST Soil Contract No: DTCG49-94- RQEN001 Delivery Order #7 July 1996 Tracen Petaluma Patrick Nelligan (707) 765-7225 | Natural Attenuation Ex-Situ | Soil 10,400 yd ³ | TPH: 0-180 ppm (avg. 50 ppm) | sandy clay, silty sand, 20% rock gw gradient: 0.006 ft/ft pH: 4.3 - 8.1 |
| PNUM X3809 Station Port Isabel S. Padre Island, TX March 1996 FD&CC LANT Jim Lewis (804) 858-6230 x225 | Natural Attenuation | soil 100 yd ³ | gasoline diesel TPH: 13,200 pp contamination depth: 0-4' bgs | dredge spoil silt and clay moisture content: 31% soil bulk density wet: 1810 g/cm ³ dry: 1.622 g/cm ³ Effective porosity: 0.446 Depth to gw: 5' bgs Organic carbon content 0.082 g/g |
| Boiler Plant, UST Bldg #15 PNUM Y4043 Baltimore, MD March 26, 1996 CG Yard Howard Galliford (410) 636-7070 | Natural Attenuation | Soil | Heavy HC's #6 heating oil TPH: 3,900 ppm | Sand, silt, clay and backfill Depth to groundwater: 14' @ UST 3' @ sump |
| PNUM M1052 Airstation Miami Opa Locka, FL Feb. 27, 1996 CEU Miami Steve Avallone (305) 278-6700 | Natural Attenuation Parsons Engineering 8100 Oak Lane, Suite 301 Miami Lakes, FL 33016 Catherine McMullen (305) 558-3002 | Water | Petroleum HC's Benzene: 6 ug/l Tot. PAH: 83 ug/l Tot. NAPHs: 4,300 ug/l Tot. lead: 50 ug/l | K: 66 cm/sec depth to gw: 4'-5' bgs gw fluctuation: 1' gw flow: northwest gw gradient: 1.0E-4 ft/ft |

4.29 (Soil) and 4.50 (Water) Natural Attenuation

| Operating Parameters | Materials Handling | Residuals Management | Cost/Comments |
|----------------------|--|----------------------|---|
| in-situ | soil okay for landfill but hauling costs are 4 -5 times the cost of onsite relocation | | \$ 57,000 stockpile spreading \$ 10,055 stockpile maintenance soil sat from 1992 to 1995 naturally degrading. plan approval by regulators pending |
| in situ | in situ | | no free product or offsite migration groundwater not impacted |
| in situ | in situ | | In-house, not monitored |
| in situ | in situ | | \$ 33,000 total cost 4 quarters of groundwater monitoring and an intrinsic remediation demonstration will be performed. |

4.29 (Soil) and 4.50 (Water) Natural Attenuation

| Site Name/ Contact | Technology/ Vendor | Media Treated | Contaminants Treated | Matrix Characteristics |
|---|------------------------|------------------|---|--|
| Isle of Shoal Light Sta. Portsmouth NH CEU Providence Rachel Marino (401) 736-1746 | Natural Attenuation | Soil | Petroleum HC's TPH: 84,000 ppm | loamy sand/bedrock depth of soil pile: 6" |
| Burnt Island Light Station Southport, ME CEU Providence Rachel Marino (401) 736-1746 | Natural Attenuation | Soil | Petroleum HC's TPH: 81,000 ppm | sandy loam/bedrock |
| Fog Signal Station Manana Island, ME February 1995 CEU Providence Rachel Marino (401) 736-1746 | Natural Attenuation | Soil | Petroleum HC's VOC: 171 ppm as of Feb. 1995 | fractured bedrock |
| West Quoddy Head Light Station Lubec, ME October 1992 CEU Providence Rachel Marino (401) 736-1746 | Natural Attenuation | Soil | Petroleum HC's VOC: 164 ppm as of Oct. 1992 | silty soil, black clay silt/bedrock depth soil pile: 1-1.5 ft |
| Nauset Light House Eastham, MA CEU Providence Rachel Marino (401) 736-1746 | Natural Attenuation | soil | Petroleum HC's Gasoline VOC: 2,500 ppm | bedrock (mostly) |

4.29 (Soil) and 4.50 (Water) Natural Attenuation

| Operating Parameters | Materials Handling | Residuals Management | Cost/Comments |
|----------------------|--------------------|----------------------|--|
| In situ | In situ | In situ | No cost bedrock located very near ground surface isolated area |
| In situ | In situ | In situ | No cost bedrock very close to ground surface isolated area |
| In situ | In situ | In situ | No cost bedrock very close to ground surface isolated area reduction in VOCs: 24 - 44 ppm as of Nov. 1995 |
| In situ | In situ | In situ | No cost bedrock very close to ground surface isolated area reduction in VOCs: 0.8 - 1.9 ppm as of Sept. 1995 |
| In situ | In situ | In situ | No cost bedrock very close to ground surface isolated area |

4.29 (Soil) and 4.50 (Water) Natural Attenuation

| Site Name/ Contact | Technology/ Vendor | Media Treated | Contaminants Treated | Matrix Characteristics |
|---|------------------------|-------------------|--------------------------------|--|
| Former Fuel Farm PNUM C3801 Air Station Elizabeth City Elizabeth City, NC 1992 CEU Cleveland Frank Blaha (216) 522-3934 | Natural Attenuation | soil and water | Petroleum HC's JP-4 release | dense clay/silt and silty clay 0-5' bgs silty sand 5'-50' bgs dense clay 50'-75' bgs K: 2.7E-4 - 1.0E-3 cm/sec depth to gw: 5'-6' bgs pH 5.5-8.5 gw gradient: 0.01-0.03 ft/ft gw velocity: 10.5 ft/yr temp.: 20-40 °C |

4.29 (Soil) and 4.50 (Water) Natural Attenuation

| Operating Parameters | Materials Handling | Residuals Management | Cost/Comments |
|--|--------------------|----------------------|---|
| In situ fate & transport of gw BTEX modeled using Bioplume II | In situ | In situ | <div> <div>\$61,600</div> <div>remed. modeling</div> <div>\$15,000/year</div> <div>O&M</div> </div> <div>Heavy contamination removed with tank hybrid system used for 2 years.</div> <div>System removed except for monitoring points.</div> <div>Complete remediation expected in 8- 12 years.</div> |

4.34 Air Sparging

| Site Name/ Contact | Technology/ Vendor | Media Treated | Contaminants Treated | Matrix Characteristics |
|--|---|------------------|---|---|
| Barrel Storage 1 Site 7A PNUM F4021 ISC Kodiak Kodiak, AK July 1996 FD&CC PAC Mike Bowlus (206) 220-7370 | Air Sparging | water | JP-5, FS-6, TCE, 1-1-1 TCE, carbon tet methylene chloride paint wastes, PCE TPH: 43-91,000 ppm Lead: 7.2 - 93.5 ppm 1,2-DCE: 10,000 ppb TCE: 12-1,600 ppb | fibrous peat: 0 - 1' bgs poorly sorted gravel: 1' - 8' bgs gravelly clay: >8' bgs K: 3.5 E-6 - 3.5 E-4 cm/sec depth to gw: 5' - 14.5' bgs pH: 5.9 - 9.1 temp: 1-15.3° C yearly O ₂ : 1.2 - 5.5 mg/L Conductance: 35 - 210 umhos/cm hardness: 59 - 515 mg/L TOC: 1.0 - 24.6 mg/L iron: 25.9 - 277 mg/L Mg: 0.96 - 10.9 mg/L |
| Laundry Loc. A Site 3 PNUM F4020 ISC Kodiak Kodiak, AK July 1996 FD&CC PAC Mike Bowlus (206) 220-7370 | Air Sparging | water | PCE: 3,000 ppb TCE: 71 ppb 1,2-DCE: 83 ppb Vinyl chloride: 440 ppb Methylene chloride: 5.5 ppb Xylene: 5.0 ppb | sandy silt, poorly graded gravel fractured bedrock: 5' - 15' bgs K: 0.02 - 3.9 cm/sec assumed porosity: 0.12 void volume: 7,900 cu. ft. depth to gw: 2' - 12' bgs perched aquifer TOC: < .21 - 1.1% CEC: 3,930 - 8,750 mg/kg |
| Fuel Farm PNUM M1055 Base Miami Beach Miami, FL 1996/97 FD&CC LANT Jim Lewis (804) 858-6230 | Air Sparging in conjunction with pump and treat (recommended for gw) | water | diesel VOA's: 108 ppm Naph: 680 ppm | silty sand K: 6.1 cm/sec Depth to gw: 5' (tidal fluctuation) Temp: approx 70° F Depth to contaminants 15 ft TDS: 17,102 mg/L Product VP 2.12 - 26.4 mm Hg |

4.34 Air Sparging

| Operating Parameters | Materials Handling | Residuals Management | Cost/Comments |
|---|--------------------|---|---|
| 2" dia pipe 4 scfm/well @ 15 psi 55 wells total (495 scfm) positive displacement pump 495 scfm @ 15 psi 60 HP, 3" dia 2950 RPM approx. 10' x 10' spacing | | | \$ 89,770 Debris removal \$ 163,368 Soil removal (1st closure attempt) \$ 5,033 Project oversight-soil removal \$ 66,000 Design \$ 850,000 Construction (estimated) |
| 17 sparge wells - 2" dia pipe 2 return well - 2" dia wells spaced @ 9'x10' interval blower: 150 scfm | | | \$ 66,561 Design \$ 45,186 Design rvw-GAC filter \$ 40,073 Construction monitoring \$ 565,451 Construction \$ 153,828 GW monitoring (1yr) |
| Air flow rate: 7 cfm per well Operating pressure: 11.4 psi Depth of sparging wells: 15' Radius of influence: 15' | | Treatment of vapors: SVE - thermal oxidation | \$ 194,000: Total capital costs for Air Sparging, free prod. recovery, and SVE Anticipated cleanup time for air sparging: 1.5 yrs. |

4.34 Air Sparging

| Site Name/ Contact | Technology/ Vendor | Media Treated | Contaminants Treated | Matrix Characteristics |
|--|---|-------------------------------|--|--|
| PNUM C9125 SARDET Holland Holland, MI Jan. 1991 - Feb. 1992 CEU Cleveland Denise Hancsak (216) 522-3934 | Air Sparging with SVE The Traverse Group, Inc. 3772 Plaza Dr. Suite 5 Ann Arbor, MI 48108 Ann Markstrom (313) 747-9300 | water 70' x 60' are | petroleum HC's diesel fuel/waste fuel BTEX PNA Oil & grease TPH | medium fine sand: 0 - 9' bgs silty layers: > 9' bgs depth to gw: 8' bgs |
| Fuel Farm PNUM M1055 Base Miami Beach Miami, FL July 1992 - Sept. 1995 CEU Miami Zonia Reyes Rob Kappel (305) 278-6700 | Air Sparging | soil 1,163 yd ³ | Petroleum HC's Gas and Diesel | fine to very fine silty sand K: 6.1 cm/sec permeability: 1.2E-4 - 3.0E-3 cm/sec depth to gw: 3' - 9' bgs pH: 7.5 - 8.1 transmissivity: 3,366 gpd/ft storativity: 0.25 |
| Pilot Study PNUM 09-C0882 Air Station Traverse City Traverse City, MI 1982 CEU Cleveland Frank Blaha (216) 522-3368 | Air Sparging Pilot Program | soil | petroleum HC's aviation gas | uniform beach sand to gray glacial silty clay K: 0.3 cm/sec |

4.34 Air Sparging

| Operating Parameters | Materials Handling | Residuals Management | Cost/Comments |
|---|---|--------------------------------|---|
| wells: 2 observation 1 monitoring 5 sparging ave. sparge pressure: 84" H ₂ O initial DO: 0.8 ppm ave. DO: 3.4 ppm bi-weekly monitoring of: BTEX PNA organic volatiles O ₂ | | off gas treatment GAC drums | \$10,180 site assessment \$36,030 remed. design, Constr., and sampling \$75/yd soil disposal |
| wells: 5 air sparging wells air flow rate: 7 cfm injection depth: 20' | in-situ in conjunction with pump and treat syst. | | See pump and treat for total project cost. |
| well dia.: 2" well spacing: 30' intervals flow rate: 100 ft ³ /min pressure: 5 psig blower rate: 10 ft ³ /min | | | \$3,600 Estimated cost |

4.37 Free Product Recovery

| Site Name/ Contact | Technology/ Vendor | Media Treated | Contaminants Treated | Matrix Characteristics |
|--|--|---|--|--|
| Navy NSFO Site RTC Yorktown Yorktown, VA March 1996 RTC Yorktown Lynn Daniels (804) 898-2390 | Free Product Recovery aided by steam injection (Navy plans) | soil: 200,000 yd ³ water | NSFO TPH in gw NSFO-soil: 0.11 - 8.8 ppm | sand, coarse to fine with some silt K: 0.4 cm/sec permeability: 1.0 E-2 cm/s depth to gw: 13' - 24' bgs gw gradient: 0.03 ft/ft gw velocity: 7.6 E-2 ft/day gw flows southwest to west 0.5' - 9.8' floating hydrocarbon lens |
| Boiler Plant, UST bldg #15 PNUM Y4043 Baltimore, MD March 26, 1996 CG Yard Howard Galliford (410) 636-7070 | Free Product Recovery with sorbent pads In-house | water | heavy HC's BTEX: 65 ppb BTEX: 58 ppb BTEX: 11 ppb TPH: 4 ppm NAPL sheen to 1" | depth to groundwater: 14' @ UST 3' @ sump gw flow is southeast |
| Fuel Farm PNUM - M1055 Base Miami Beach July 1992-Sept. 1995 CEU Miami Zonia Reyes/ Rob Kappel (305) 278-6700 | Free Product Recovery | water | petroleum HC's gas and diesel | fine-very fine silty sand K: 6.1 cm/sec permeability: 3.8 E-6 - 1E-4 ft/sec depth to gw: 3'-9' bgs (tidal influence) gw flow toward bay pH: 7.5-8.1 Transmissivity: 3366 gpd/ft Aquifer thickness: 15' |
| Fuel Farm PNUM C3802 Air Station Elizabeth City Elizabeth City, NC CEU Cleveland Jim Vardy (919) 335-6847 | Free Product Recovery Engineering- Science, Inc One Harrison Park 401 Harrison Oaks Blvd., Suite 305 Cary, NC 27513 (919) 677-0080 Donald Boyle | water: 3.2 acres (area) | Petroleum HC's Fuel (POL), JP-5 TPH, BTEX, VOAs, SVOAs TPH: 51-6490 mg/kg VOA: >10 ppm SVOA: >40 ppm free product levels: est. several thousand gal. | clay, silty loam 0 - 5' bgs silty fine sand 5' - 67' bgs grain size: 0.074-2.0mm K _{avg} : 0.4 cm/sec moisture content: .16-.25 permeability: .25 horiz. perm. 4.5 E-10 depth to gw: 8'-9' bgs gw gradient 0.001-0.005 ft/ft pH 4.6-7.0 temp 10.9-16.6 °C |

4.37 Free Product Recovery

| Operating Parameters | Materials Handling | Residuals Management | Cost/Comments |
|--|--------------------|-----------------------|---|
| above ground oil/water separators - planned by Navy. disposal of product-recycling planned disposal method of water - on site UV/Oxidation (Navy) | | | The RTC Site is a small part of a large Navy spill, remediation of RTC's segment will depend on what the Navy does. |
| free product removal with sorbent pads in-house monitored | in-house | disposed as used oil. | |
| free product recovery in conjunction with pump and treat system oil/water separator is connected to a sump tank. | | | See pump and treat for total project costs. |
| in well skimmers recovery well every 100' pipe gravity flow to sumps drain pipes at water/product interface rad. of infl.: 25'-30' product recovery: 60 gal/day | | | \$350,000 construction \$ 30,000 maint. & monitoring \$500,000 demolition & removal of fuel farm |

4.37 Free Product Recovery

| Site Name/ Contact | Technology/ Vendor | Media Treated | Contaminants Treated | Matrix Characteristics |
|---|---|------------------|-------------------------|---|
| PNUM C0805 Sta. Little Creek, Norfolk, VA 1992 Cleveland CEU Denise Hancsak (216) 522-3934 x.267 | Free Product Recovery EA Engineering, Science and Technology 15 Loveton Circle Sparks, MD 21152 (410) 771-4950 | water | petroleum HC's BTEX | K: 0.7-3.1 cm/sec porosity: 0.25 depth to gw: 8'-10' bgs gw fluctuations: 0.3'-1.3' gw velocity: 0.02-0.07 ft/day gw gradient: 0.0012 ft/ft transmissivity: 800-3700 gpd/ft perched groundwater: 5' - 8' bgs aquifer thickness: 33' |

4.37 Free Product Recovery

| Operating Parameters | Materials Handling | Residuals Management | Cost/Comments |
|--|--------------------|----------------------|---------------|
| in line filter remove 8-10 micron particle at efficiency of 97-98% | | | |
| 1 soil sample annually for BTEX and TPH | | | |
| 1 gw sample quarterly for BTEX and TPH | | | |

4.44 Air Stripping

| Site Name/ Contact | Technology/ Vendor | Media Treated | Contaminants Treated | Matrix Characteristics |
|--|--|---|---|---|
| Fuel Farm PNUM - M1055 Base Miami Beach Miami, FL July 1992- Sept. 1995 CEU Miami Zonia Reyes/ Rob Kappel (305) 278-6700 | Air Stripping | groundwater soil: 1,163 yd ³ | petroleum HC's gas and diesel | fine, very fine silty sand K: 6 cm/sec permeability: 3.8 E-6 - 1.0 E-4 ft/sec depth to gw: 3'-9' bgs (tidal influence) gw flows toward bay pH: 7.5-8.1 transmissivity: 3,366 gpd/ft Aq. thickness: 15' |
| PNUM P1813 Air Station Brooklyn Brooklyn, NY 1987-1994 CEU Providence Rachel Marino (401) 736-1746 | Air Stripping Tyree Brothers Environmental | groundwater | petroleum HC's aviation Fuel VOCs | K: 1.3 E-4 - 4.3E-4 cm/sec porosity: 0.35 - 0.36 depth to gw: 7' - 11' bgs gw flow rate: 36 ft/year product thickness: 0-3.47' |
| PNUM P1813 Air Station Brooklyn Brooklyn, NY 1991-1992 CEU Providence Rachel Marino (401) 736-1746 | Air Stripping H&GCL, Inc. 300 Metro Center Blvd. Warwick, RI | Groundwater | Petroleum HC's JP-4 TPH: 0.28-1.26 mg/l Benzene: 5-260 ug/l Toluene: 5-12 ug/l Ethylbenzene: 5-140 ug/l Xylene: 5-520 ug/l | depth to gw: 6.7'-12.0' bgs tidal fluctuation: 0.4' product thickness: 3.23' |
| PNUM C0860 Base Milwaukee Milwaukee, WI Feb. 1996 CEU Cleveland Denise Hancsak (216) 522-3934 (ext.267) | Air Stripping | air from soil vapor extraction operation | petroleum HC's gasoline/diesel Soil: DRO Water: BTEX ethylbenzene DRO | clay to silty clay 1'-7' bgs silty sand >7' K: 6.9xE-4 cm/sec depth to gw: 5'-10' bgs |

4.44 Air Stripping

| Operating Parameters | Materials Handling | Residuals Management | Cost/Comments |
|--|---|--|--|
| air stripper: temp.: 70° F air flow: 600 cfm water flow: 12 gpm | in situ - in conjunction with pump and treat system. | | see pump and treat for total project costs, pg 3-61. |
| in situ capacity of airstripper: 30 gpm pump rate: 2.75 hp | free product recovery using petropurge pump water pumped using a submersible hydropurge pump | product recovery tanks no off gas treatment | \$3,350/month O&M |
| air stripper influent: 13-33 gpm radius of influence: 30'-60' | recovery: 100,000 gal. of JP-4 | off gas treated with carbon. | |
| air stripper: max flow rate: 10 gpm | in situ | | |

4.47 (Liquid) and 4.55 (Vapor) Phase Carbon Adsorption

| Site Name/ Contact | Technology/ Vendor | Media Treated | Contaminants Treated | Matrix Characteristics |
|--|---|------------------|---|---|
| Taxiway C spill PNUM O1499 Air Station San Francisco San Francisco, CA January 1995 CEU Oakland Joseph Sabel (510) 535-7239 | Liquid Phase Carbon Adsorption WCC Oakland, CA Carrie Austin (510) 893-3600 | groundwater | petroleum HC's gasoline/jet fuel Soil Contamination: TPH: 1100 mg/kg Toluene: 360 ug/kg Ethylbenzene: 5.7 ug/kg Xylene: 6100 ug/kg groundwater: jet fuel 23,000 ug/l | stiff clay and sand depth to gw: sea level near shore inland up to 5ft bgs |
| Fuel Farm PNUM - M1055 Base Miami Beach Miami, FL July 1992- Sept. 1995 CEU Miami Zonia Reyes/ Rob Kappel (305) 278-6700 | Carbon Adsorption | groundwater | petroleum HC's gas and diesel | fine, very fine silty sand K: 6 cm/sec permeability: 3.8 E-6 - 1.0 E-4 ft/sec depth to gw: 3'-9' bgs (tidal influence) gw flows toward bay pH: 7.5-8.1 transmissivity: 3,366 gpd/ft Aq. thickness: 15' |

4.47 (Liquid) and 4.55 (Vapor) Phase Carbon Adsorption

| Operating Parameters | Materials Handling | Residuals Management | Cost/Comments |
|--|--|---|--|
| avg. groundwater pumping: 3600 gal/d air supply: 8-10 psig; collection/interceptor trench: thickness: 9' trench bottom 3ft below water table. transfer pump flow: 10 gpm 2-1000lb carbon vessels | replacement carbon vessels annually breakthrough monitoring: every 2wks for 3 mo. monthly thereafter analyze TPH, VOA | GAC treated water discharged to industrial waste line. | \$101,369: total cost \$2.25/lb carbon replacement work scheduled to be completed 9/30/96. |
| Loading rate for GAC: 1.89 gpm/ft ² used in conjunction with pump and treat system | 6 GAC canisters: 200 lbs each used in conjunction with pump and treat system | Treated groundwater will be discharged to stormwater system. NPDES permit required. | See pump and treat for total project costs. |

Asphalt Cap

| Site Name/ Contact | Technology/ Vendor | Media Treated | Contaminants Treated | Matrix Characteristics |
|---|-----------------------|--------------------------------|---|--|
| Barrel Storage 1 Site 7A PNUM F4021 ISC Kodiak Kodiak, AK July 1996 FDCC PAC Mike Bowlus (206) 220-7370 | Asphalt Cap | Soil 27,000 ft ² | JP-5, FS-6, TCE, 1-1-1 TCE carbon tet methylene chloride paint wastes, PCE. TPH: 43-91,000 ppm Lead: 7.2-93.5 ppm 1,2-DCE: 10,000 ppb TCE: 12-1,600 ppb | fibrous peat 0 - 1' bgs poorly sorted gravel 1' - 8' bgs gravelly clay >8' bgs K: 3.5 E-6 - 3.5 E-4 cm/sec depth to gw: 5' - 14.5' bgs pH: 5.9 - 9.1 temp: 1 - 15.3° C yearly O ₂ : 1.2 - 5.5 mg/L TOC: 1.0 - 24.6 mg/L iron: 25.9 - 277 mg/L Mg: 0.96 - 10.9 mg/L Conductance: 35 - 210 umhos/cm hardness: 59 - 515 mg/L |
| Site 6A - MOGAS PNUM F4016 ISC Kodiak, AK Kodiak, AK July 1995 FDCC PAC Mike Bowlus (206) 220-7370 | Asphalt Cap | Soil 27,200 ft ² | JP-5, used oil, waste solvents contaminants > background levels TPH: 14,200 ppm PCE: 3,500 ppb | organic soil 0-1' bgs sand, gravelly with silt 1'-17' bgs (.5" - 1.0" dia) fractured bedrock @ 17' - 21' K: 4.2E-4 - 8.7E-3 cm/sec porosity assumed: 0.12 void volume: 48,000cu. ft. gw gradient: .02 - .88 ft/ft |
| Laundry Loc. A Site 3 PNUM F4020 ISC Kodiak Kodiak, AK July 1996 FDCC PAC Mike Bowlus (206) 220-7370 | Asphalt Cap | Soil 5,400 ft ² | PCE: 0.02-1700 ppm TCE: 0.065-0.380 pp 1,2-DCE: 0.190 ppm TPH: 60-260 ppm vinyl chloride: 0.22 ppm chloroethylene: 1.1 ppm | sandy silt, poorly graded gravel 0 - 5' bgs fractured bedrock 5' - 15' bgs K: 0.2 - 3.9 cm/sec void volume: 7,900 ft ³ assumed porosity: 0.12 depth to gw: 2' - 12' bgs perched aquifer TOC: < .21 - 1.1% CEC: 3,930 - 8,750 mg/kg |

Asphalt Cap

| Operating Parameters | Materials Handling | Residuals Management | Cost/Comments |
|--|---|---|---|
| asphalt cap design: area: 27,800 ft ² seal coat cover asphalt: 3" base course: 4" subbase: 6" geotextile geomembrane geotextile 11" controlled fill for slope drainage (2%) SVE piping | | Perimeter trench drains (6" dia) | SVE, air sparging, and asphalt cap were used on this project. The following costs are total costs for all three technologies: \$ 66,000 Design \$ 5,033 Project oversight -soil removal \$ 89,770 Debris removal \$ 163,368 Soil removal (1st closure attempt) \$ 850,000 Construction (estimated) |
| asphalt cap design: seal coat cover asphalt: 3" base course: 4" subbase: 6" geomembrane (60 mil, LDPE) 5" controlled fill for slope drainage (1.5-3.0%) 6" under drain collection pipe | | 6" under drain collection pipe | Bioventing and asphalt cap were used on this project. The following costs are total costs for both technologies: \$ 907,661 well installation @ MOGAS and laundry |
| asphalt cap design: seal coat cover asphalt: 3" base course: 4" subbase: 6" geomembrane (60 mil LDPE) 11" controlled fill for 3% slope | collection sump is pumped to 1,200 gal. AST | 8" under drain collection pipe Collection sump is pumped to 1,200 AST | SVE, air sparging, and asphalt cap were used on this project. The following costs are total costs for all three technologies: \$ 66,561 Design \$ 45,186 Design rvw-GAC filter \$ 565,451 Construction \$ 40,073 Const. monitoring \$ 153,828 GW monitoring (1yr) |

Excavation

| Site Name/ Contact | Technology/ Vendor | Media Treated | Contaminants Treated | Matrix Characteristics |
|--|-----------------------|------------------------------|--|--|
| Drum & Barrel Disposal Area Site 24 PNUM F4046 ISC Kodiak Kodiak, AK July 1996 FDCC PAC Mike Bowlus (206) 220-7370 | Excavation | soil: 166 yd ³ | TPH: 100-100,000 pp cleanup level 200 ppm | clayey and silty gravel depth to gw: 10' - 12' bgs |
| Quartermaster Gas Station Site 14 PNUM F4036 ISC Kodiak Kodiak, AK July 1996 FDCC PAC Mike Bowlus (206) 220-7370 | Excavation | soil: 460 yd ³ | 2,250 gal. of product | gravel fill 0 - 4' bgs coarse sand/gravel 4'-19' bgs depth to gw: 11'-12' bgs 200 ft from river |
| Projects 4007 & 4008 RTC Yorktown Yorktown, VA March 1996 RTC Yorktown Lynn Daniels (804) 898-2390 Roger West (804) 898-2148 | Excavation | soil: 5 yd ³ | DDT: <1ppm DDE: <10ppm | |

Excavation

| Operating Parameters | Materials Handling | Residuals Management | Cost/Comments |
|---|---|--|--|
| | 1,000 lb of removed vegetation was landfilled soil stockpiled for future remediation by Nyman's Biocell | 1,000 lb of removed vegetation was landfilled | \$ 25,000 Debris removal \$ 24,174 Drum removal \$140,164 Soil removal |
| 15 - 5,000 gal UST cleaned, cut, and disposed (56 tons) | soil sampled every 10 - 15 cu yd (truckload) soil piles segregated by contamination levels: > 2,200 ppm TPH < 2,200 ppm TPH < 400 ppm TPH | 6,075 gal liquid waste req. hazardous waste disposal 665 gals (10 drums) solid hazardous waste. 50,000 gals water filtered for POTW disposal filtration: 1st thru 10 micron filter 2nd 110 GAC filter 3rd 110 gallon ion exchange unit (metal) | \$ 93,333 site investigation \$ 6,567 liquids disposal \$649,317 construction \$ 43,873 gw monitoring |
| | 3 - 55 gal drums to DRMO 14000 lb contaminated soil | | \$55,000 total cost |

Excavation

| Site Name/ Contact | Technology/ Vendor | Media Treated | Contaminants Treated | Matrix Characteristics |
|--|--|--|--|---|
| UST Removal PNUM X0819 Sta. Chincoteague Chincoteague, VA FDCC LANT Jim Lewis (804) 858-6230 | Excavation Recycling Alternatives - Chance Constr. Co. | soil: 26 yd ³ | diesel #2 heating oil: 32 - 800 ppm | sediment sandy silt |
| PNUM X3400 Sta. Clearwater Clearwater, FL FDCC LANT Jim Lewis (804) 858-6230 | Excavation | soil: 1,580 tons | gasoline BTEX: 40 ppm | sand |
| Boiler Plant, UST Bldg #15 PNUM Y4043 Baltimore, MD March 1996 CG Yard Howard Galliford (410) 636-7070 Fax: (410) 636-7692 | Excavation (partial) | soil | heavy HC's TPH: 3,900 ppm | sand, silt, clay and backfill Depth to gw: 14' @ UST 3' @ sump |
| 15 Mohegan Ave. PNUM 7057B Contract No.: DTCG39-91-B USCG Academy Groton, CT USCG Academy LTJG Tim Opstrup (860) 444-8233 Fax: (860) 444-8219 | Excavation Pollution Solutions of Vermont, Inc. | soil: 90 tons gw: potentially | waste oil solvents BTEX: 16-200 ppm tetrachloroethylene: 113 ppm 111-trichloroethylene: 67 ppm | coarse sand and gravel fractured bedrock groundwater flows east |
| PNUM M1583 Sta. Venice Venice, FL 1994 CEU Miami Zonia Reyes (305) 278-6700 | Excavation and Disposal Vaughn Companies (504) 436-0808 Mr. Vaughn Rubark Env. Services (504) 944-9965 | soil water | petroleum HC's diesel fuel | medium to fine sand |

Excavation

| Operating Parameters | Materials Handling | Residuals Management | Cost/Comments |
|--|--|---|--|
| | recycled/thermal treatment - 560 tons | | \$80 - \$133 /cu yd cost included: excavation treatment backfill |
| | soil disposed as contaminated fill. | 1,000 tons of contaminated soil remained on site. | \$75 / ton unit cost |
| 523 tons contaminated soil removed to date | | | \$90/ton disposal and transport |
| 90 tons soil excavated in 1991 add. sampling underway | | | \$1,272/ton unit cost |
| | cont. soil: placed in drums for haz. waste disposal | monthly monitoring | \$ 17,000 CAR \$ 70,000 Phase I & II \$118,800 CARA |

Excavation

| Site Name/ Contact | Technology/ Vendor | Media Treated | Contaminants Treated | Matrix Characteristics |
|--|--|--|---|--|
| UST Leak PNUM - M0190/M1049 Base Mayport Mayport, FL CEU Miami Zonia Reyes (305) 278-6700 | Phase I Remediation - Excavation and Disposal Phase II remediation planned for 1997 Technology Unknown | soil; 750 ton 540 yd ³ (phase I) | petroleum HC's diesel fuel free product TPH: 1,490 mg/kg | fine-med silty sand K: 0.7 cm/sec porosity: 0.25 depth to gw: 3'-4' bgs (tidal influence: 0.1'-.2' bgs) pH: 6.9-8.7 gw gradient: 0.02 ft/ft pore water vel.: 1.02 ft/day temp.: 25.4-28.4 °C transmissivity: 102.2 ft ² /day |

Excavation

| Operating Parameters | Materials Handling | Residuals Management | Cost/Comments |
|-------------------------|-----------------------|-------------------------|--|
| | Ex situ | | Phase I costs: \$23,200 CAR \$6,000 CAP |

Pump and Treat

| Site Name/ Contact | Technology/ Vendor | Media Treated | Contaminant Treated | Matrix Characteristics |
|--|---|------------------|----------------------------------|---|
| Fuel Farm PNUM - M1055 Base Miami Beach Miami, FL July 1992 -Sept. 1995 Miami CEU Zonia Reyes/ Rob Kappel (305) 536-6722 | Pump and Treat Air Stripper with GAC IRA: Barrington Petroleum Contractors CAR: Gehraghty & Miller RAP: PSI: Remediation: TBD | groundwater | Petroleum HC's Gas and Diesel | fine, very fine silty sand K: 6 cm/sec permeability: 4.0 E-6 -1.0 E-4 ft/s depth to gw: 3'-9' bgs (tidal influence) gw flow toward bay pH: 7.5 - 8.1 Transmissivity: 3366 gpd/ft Aquifer thickness: 15 ft |

Pump and Treat

| Operating Parameters | Materials Handling | Residuals Management | Cost/Comments |
|---|--|---|--|
| Recovery wells: screen length: 15' drawdown: 1.5' Q_{air} : 600 cfm Q_{water} : 12 gpm Loading rate for GAC: 1.89 gpm/ft ² | 6 GAC canisters of 200 lbs each Oil/water separator is connected to a sump tank in conjunction with soil vapor extraction | Treated groundwater will be discharged to stormwater system. NPDES permit required | \$200,000 construction \$280,000 O&M 4 yrs. \$278,000 CARA \$110,000 power \$240,000 fuel \$ 16,000 IRA \$ 75,000 CAR \$ 33,250 RAP \$ 8,000 CAP |